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Moab Site Project

Work Plan for Characterization of Groundwater Brine Zones for Interim Remediation Activities

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1.0 Introduction

The Moab, Utah, Uranium Mill Tailings Remedial Action (UMTRA) Project Site (Moab site) is a former uranium ore-processing facility located approximately 3 miles northwest of the city of Moab in Grand County, Utah. The plant was constructed in 1956 by the Uranium Reduction Company, which operated the mill until 1962 when the assets were sold to the Atlas Minerals Corporation (Atlas). Operations continued under Atlas until 1984. When the processing operations ceased in 1984, approximately 130 acres of mill tailings had been impounded in an unlined pond located near the northwest portion of the property. Atlas placed an interim cover over the tailings pile as part of decommissioning activities on-going between 1988 and 1995. In October 2001, the title of the property and responsibility for remediation of the tailing pile and contaminated groundwater beneath and downgradient from the site was transferred to the Department of Energy (DOE).

Results of previous investigations (ORNL 1998 and SMI 2001) suggest that the former operating practices have impacted the shallow groundwater with site related contaminants. Characterization data indicate that some of the more mobile contaminants have infiltrated to the groundwater and are migrating downgradient from the tailings pile in a plume that is discharging to the Colorado River. Stakeholders have expressed concern about ecological risks to the sensitive aquatic species that inhabit the bank of the river where ammonia is discharging. Additional characterization of the aquifer is required to support the design of an interim remedial action to reduce risk to endangered fish from ammonia discharge to the river (DOE 2001).

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2.0 Purpose and Goals

Fresh water in the unconfined alluvial system at the Moab site is underlain by a salt water brine zone. Pumping from the shallow fresh water system (during pump-and-treat remediation) may cause the salt water to rise to a higher elevation and intrude the fresh water. Salt-water intrusion would result in degradation of the overlying fresh water, which could adversely impact the tamarisk plant communities that are providing beneficial phytoremediation at the site. Besides causing salt-water intrusion into the shallow groundwater, rising salt water may bring higher ammonia concentrations to the surface and cause added contamination to the river.

Characterization tasks described in this work plan are intended to provide empirical data regarding the up coning of the brine by a well pumping from the overlying freshwater system. Results from this characterization effort will be used to prepare a design for an interim remediation action to reduce the risk to potentially sensitive habitat along the Colorado River that are impacted by relatively high ammonia concentrations. Primary objectives for the characterization activities are listed below:

- Characterize the nature of the fresh-water-brine contact at several existing pumping well locations.

- Evaluate the relationship between drawdown in the fresh water zone and up coning response in the brine zone at different pumping rates and pump intake locations.

- Determine the maximum pump rate that can be sustained without any rise in the underlying brine zone.

A secondary objective of this study is to acquire additional data to determine hydraulic parameters of the shallow aquifer. However, because of the density differences in the ground water due to the brine, not all the field tests proposed in this work plan may be applicable for hydraulic analysis. For this reason, collection of hydraulic parameters of the aquifer is a secondary objective.

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3.0 Background Information

The Moab site lies upon an aquifer that consists of a mixture of Quaternary alluvium, talus, and eolian deposits. These alluvium deposits are divided into shallow sandy sediments and deeper gravelly sediments. The shallow deposits are fine-grained, well-graded, sands and silts that range in thickness from approximately 8 to 30 feet (ft), with a site average of 20 ft. Gravelly sands and sandy gravels make up the deeper alluvium, with the thickness dependent upon the depth to bedrock. Depth to bedrock varies dramatically across the site, with the range of thickness not clearly defined. There are no boreholes that have been drilled to bedrock beneath the tailings pile or the former millsite area. Based on the available data the bedrock crops out north of Highway 191, and is greater than 400 ft below the ground surface near the southeast corner of the tailings pile.

3.1 Groundwater Zones

Shepherd Miller, Inc. installed three nested well clusters to evaluate hydraulic properties of the shallow alluvial aquifer (SMI 2001). The locations of the well clusters are shown in Figure 1. All three well clusters consist of a single pumping well and three observation wells. Observation wells for two of the well clusters (SMI–PW01 and SMI–PW03) are screened at a shallow, intermediate, and deep depth interval. Observation wells for the other well cluster (SMI–PW02) includes two wells screened at an intermediate depth and one well screened at a deep depth.

During the installation of these well clusters and other borings across the site, SMI monitored the conductivity of the water encountered at various depths. Based on this data, SMI divided the groundwater system into three zones; a shallow freshwater zone, an intermediate brine/freshwater transition zone, and a deep brine zone. In general:

- Depth to the freshwater surface across the site ranges from approximately 15 to 50 ft. This freshwater zone is approximately 30 to 60 ft thick and has a density of 1.00 to 1.02 grams per cubic centimeter (g/cm^3).
- The transition zone overlying the brine is generally 20 to 25 ft thick, and is thought to be the result of the rising and lowering of the water table. Depth to the top of this transition zone range from 30 ft (in the vicinity of SMI–BH–09) to 55 ft below ground surface bgs (in the vicinity of SMI–PZ1D2). The depth to top of the transition zone decreases towards the Colorado River.
- The depth to the top of the brine, which has a density of 1.06 to 1.10 g/cm^3, ranges from 59 ft (measured near SMI–BH–08) and 79 ft bgs (SMI–PZ1D2).

During the installation of the SMI well clusters and SMI–BH–08 (Figure 1) the conductivity at various depths was measured. Conductivity values are an easy field parameter to measure and are indicative of the changing water quality encountered. As shown on Figure 1, SMI–BH–08 lies between the SMI–PW01 and SMI–PW02 clusters (approximately 300 ft northeast of SMI–PW02), along the bank of the Colorado River. Field conductivity data collected by SMI during the well and boring installation are listed in Table 1 and graphically illustrated in Figure 2. Boring logs are contained in Appendix A.

Table 1. Groundwater Conductivity Measured at the SMI–PW Clusters and SMI–BH–08

SMI–PW01[a]		SMI–PW02[b]		SMI–PW03[c]		SMI–BH–08	
Depth (ft bgs)	**Conductivity (µS/cm)**	**Depth (ft bgs)**	**Conductivity (µS/cm)**	**Depth (ft bgs)**	**Conductivity (µS/cm)**	**Depth (ft bgs)**	**Conductivity (µS/cm)**
23	6940	32	20100	53	9370	22	11650
33	18690	42	29500	62	8610	32	25700
43	23800	51	41200	73	7240	42	53700
53	23900	62	87300	83	36100	52	71200
63	64900	72	99400			62	91900
73	67900	82	107400			72	102100
83	98900					78	107500

[a] Conductivity measurements collected during the installation of piezometer SMI–PZ1D2 for this location
[b] Conductivity measurements collected during the installation of piezometer SMI–PZ2D for this location
[c] Conductivity measurements collected during the installation of piezometer SMI–PZ3D2 for this location

Based on the data presented in Table 1 and plotted in Figure 2, the conductivity of the groundwater increases with depth and reaches approximately 100,000 microSiemens per centimeter (µS/cm) at a depth of 70 to 80 ft bgs at each of the locations with the exception of SMI–PW03. At the SMI–PW03 location, the conductivity at 83 ft was 36,100 µS/cm, suggesting the top of the brine zone may be greater than 83 ft at this location.

SMI reports information regarding the depth to the freshwater/brine interface and the underlying brine zone at each of the three PW well cluster locations. Even though discrete depths were mentioned to each of these zones, there appears to be no mention regarding the criteria used to distinguish these zones (i.e., the conductivity range used to describe each water zone is not provided). In summary:

- At the SMI–PW01 location there is a reported freshwater saturated thickness of 46 ft. Taking into account a static water level of approximately 9.5 ft bgs (measured November 2000), the top of the freshwater/brine interface is expected to be encountered at a depth of approximately 55 ft bgs. Assuming the average thickness for this unit of 20 to 25 ft, the top of the brine is expected to be from 75 to 80 ft bgs. These estimates coincide well with the conductivity data collected in the field and presented in Table 1. There is a large increase in the conductivity between 53 and 63 ft bgs, and again from 73 to 83 ft bgs.

- A reportedly thinner freshwater saturated thickness of 28 ft was measured at the SMI–PW02 location. With a static water level of 9.3 ft bgs (measured November 2000), the top of the interface zone is expected to be at a depth of approximately 38 ft bgs. Again assuming this interface zone is from 20 to 25 ft thick; the top of the brine is expected to be at a depth from 58 to 63 ft bgs. The estimated depth to the top of the brine coincides well with the data collected during the well installation, which shows a large increase in the conductivity from 51 to 62 ft bgs (Table 1). However, the depth to the top of the interface zone cannot be as easily compared due to the limited shallow field data collected.

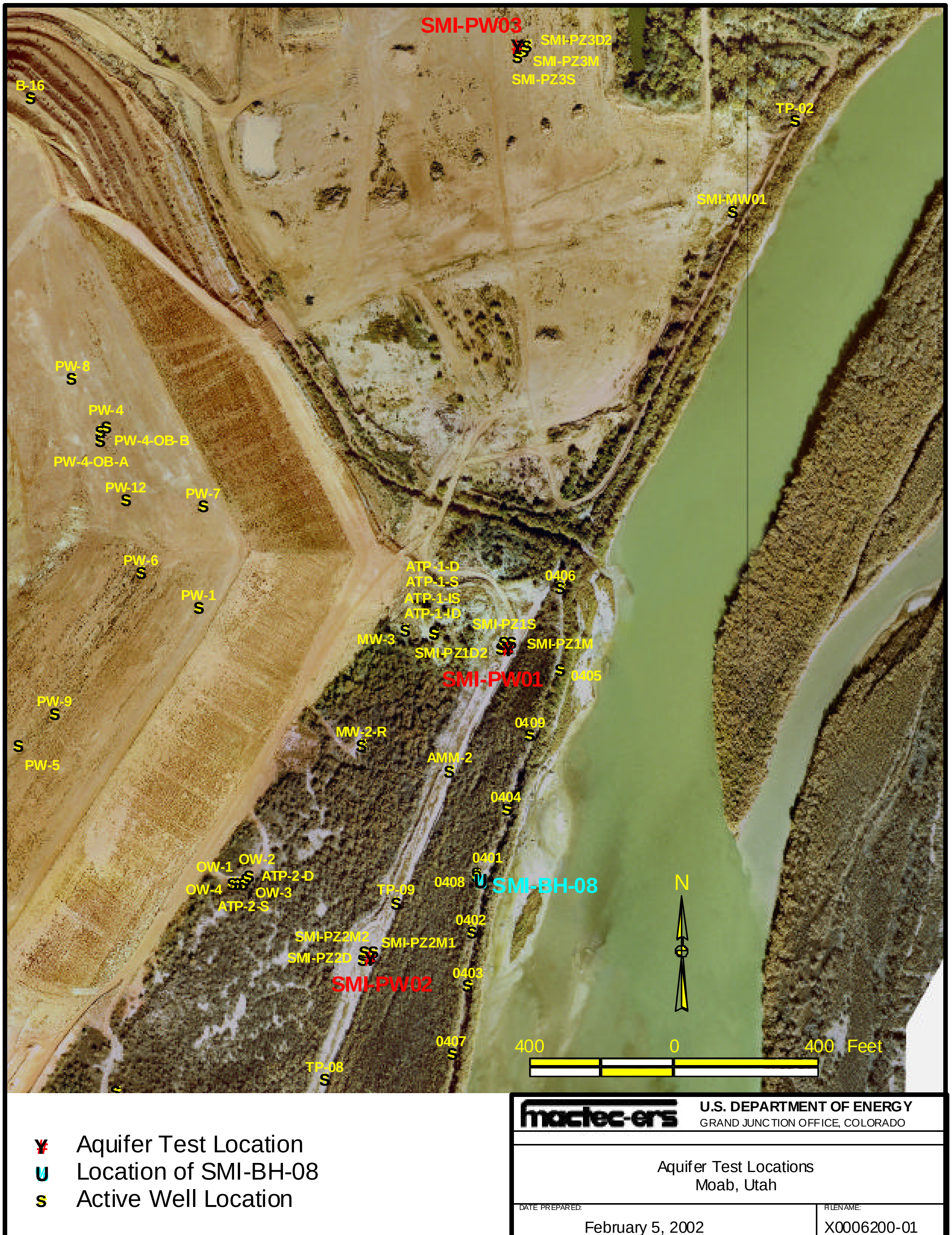

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Figure 1 Well Location Map

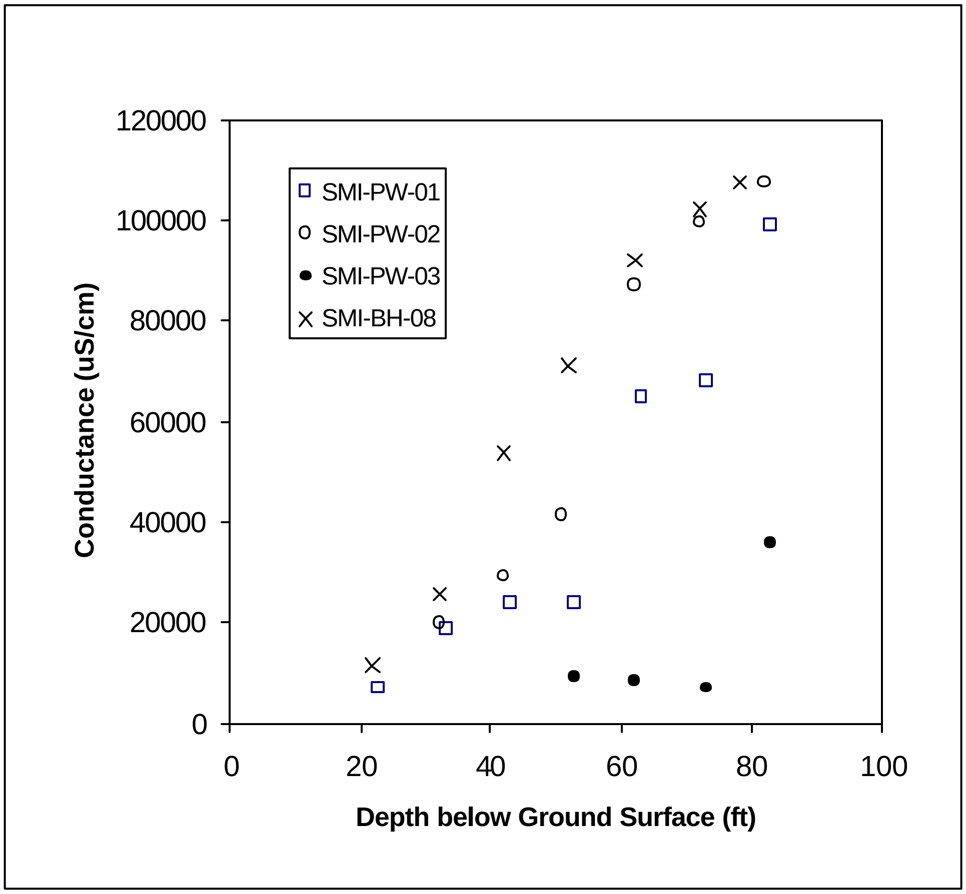

Figure 2. Ground Water Conductivity as a Function of Depth

- SMI reported that the freshwater/brine interface was not encountered during the investigation at the SMI–PW03 location, where there is a freshwater saturated thickness of approximately 55 ft. However, as shown in Table 1 and presented Figure 2, there appears to be a significant conductivity increase between 73 and 83 ft bgs, suggesting the top of the freshwater/brine interface may be encountered at this depth.

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4.0 Previous Aquifer Testing

A number of aquifer and slug tests have been performed onsite in various locations to determine the hydraulic parameters of the aquifer. In addition to monitoring drawdown to determine aquifer parameters, the tests completed during the SMI 2000 field investigation also monitored groundwater conductivity changes in response to the groundwater pumping.

During each of the tests the pump intake was set approximately at the midpoint of pumping well screen interval (approximately 40 ft bgs). A probe designed to measure conductivity, pH, and temperature was set below the pump in the pumping well and inside the screened interval only for the deepest observation well to monitor changes in the groundwater during the tests. Equipment failure resulted in conductivity data collection from the pumping well only during the SMI–PW01 test. Conductivity data was collected from the deepest observation well at each of the 3 test locations. Well completion logs and cross-sections of each of the well clusters are contained in Appendix B.

4.1 SMI–PW01 Aquifer Test

The most complete data set is associated with the test completed at the SMI–PW01 location. This test ran for 24.2 hours (hr) at pumping rates of 78 gpm (from the start of the test to approximately 0.5 hr into the test) and 58 gpm (from 0.5 hr until the end of the test). Table 2 lists the drawdown measured at the pumping and observation wells, plus the conductivity values measured during the aquifer test.

Table 2. Summary of Drawdown and Conductivity Data from SMI–PW01 Aquifer Test

Well	r (ft)	Screened Interval (ft)	Total drawdown (ft)	Initial Conductivity (μS/cm)	Conductivity at t = 24 hrs (μS/cm)	Conductivity after 6 hrs of recovery (μS/cm)
SMI–PW01	0	20.1 – 60.1	4.2	19,480	63,880	24,080
SMI–PZ1S	19	13.9 – 19.1	na	na	na	na
SMI–PZ1M	24	55.5 – 60.8	2.1	na	na	na
SMI–PZ1D2	22	69.8 – 75.0	1.1*	51,540	48,950	48,270

Notes: r = radial distance from the pumping well to the observation well
* = this drawdown may be influenced by the groundwater density, since this well is screened near the top of the brine zone.

While the data collected from the pumping well exhibits a drastic change in the conductivity during the aquifer test, the conductivity data associated with the deep observation well does not fluctuate significantly. Compared to the “background” data collected during the installation of SMI–PZ1D2 (Table 1), the conductivity values are lower than expected. The data presented in Table 1 indicate the conductivity of the groundwater in the screened interval was expected to be closer to 67,000 µS/cm. Appendix C contains the conductivity versus time plots for data collected from the pumping well and the deepest observation well.

4.2 SMI–PW02 Aquifer Test

Apparently neither drawdown nor conductivity data was collected from the pumping well during the SMI–PW02 aquifer test. This aquifer test was run for 22.7 hrs at a pumping rate of 61 gpm. A summary of the available drawdown and conductivity data is presented in Table 3.

Table 3. Summary of Drawdown and Conductivity Data From SMI–PW02 Aquifer Test

Well	r (ft)	Screened Interval (ft)	Total drawdown (ft)	Initial Conductivity (μS/cm)	Conductivity at t = 22.7 hrs (μS/cm)	Conductivity after 7 hrs of recovery (μS/cm)
SMI–PW02	0	20.0 – 60.3	na	na	na	na
SMI–PZ2M1	21	55.0 – 60.3	1.0	na	na	na
SMI–PZ2M2	23	55.1 – 60.4	1.0	na	na	na
SMI–PZ2D	22	73.2 – 78.5	0.9[a]	151,429	152,200	152,010

Notes: r = radial distance from the pumping well to the observation well
* = this drawdown may be influenced by the groundwater density, since this well is screened near the top of the brine zone.

Compared to Table 1 data, the conductivity measured during this aquifer test is considerably higher (approximately 150,000 μS/cm versus 100,000 μS/cm). The conductivity versus time plot for observation well SMI–PZ2D is contained in Appendix C. As this plot shows, practically no change in the conductivity was measured during the pumping phase of the aquifer test and over 7 hrs of the recovery test.

4.3 SMI–PW03 Aquifer Test

The aquifer test completed at the SMI–PW03 cluster consisted of 24.2 hrs of pumping at a rate of 72 gpm followed by a 7 hr recovery test. The available data are summarized in Table 4.

Table 4. Summary of Drawdown and Conductivity Data From SMI–PW03 Aquifer Test

Well	r (ft)	Screened Interval (ft)	Total drawdown (ft)	Initial Conductivity (μS/cm)	Conductivity at t = 24.2 hrs (μS/cm)	Conductivity after 7 hrs of recovery (μS/cm)
SMI–PW03	0	20.2 – 60.5	na	na	na	na
SMI–PZ3S	28	21.9 – 27.2	na	na	na	na
SMI–PZ3M	19	54.8 – 60.1	2.2	na	na	na
SMI–PZ3D2	27	75.3 – 80.6	0.6	64	28,190	28,280

Notes: r = radial distance from the pumping well to the observation well

The initial conductivity value of 64 μS/cm may not be representative, and may be a function of the instrumentation. The data indicate the conductivity remained at 64 μS/cm through 1.5 minutes (min.) into the test, and at 2 min increased to 24, 950 μS/cm, and up to 27,120 μS/cm after 2.5 min. From this point of the test, the conductivity stabilized and did not fluctuate drastically throughout the remainder of the pumping phase or the recovery phase of the test. The conductivity versus time plot for observation well SMI–PZ3D2 is also contained in Appendix C.

5.0 Field Investigation Approach

The field investigation described in the work plan is divided into two parts; 1) a reconnaissance survey to collected background water chemistry data and static water elevations, and 2) a field test to be completed at up to three pumping well locations.

After the reconnaissance survey is completed, a review of the data will provide a basis for developing a criterion that can be used to determine the water type encountered at other locations across the site. The data will also provide insight into the groundwater types encountered at each location, and the depths at which the groundwater transitions from freshwater into brine.

5.1 Reconnaissance Survey

The reconnaissance survey will focus upon the characterization of the groundwater at each of the three PW well cluster locations. It is imperative to determine the static groundwater conditions at each of these locations prior to completion of the field study.

As the cross-sections in Appendix B show, in general the pumping well at each of the three locations is screened from 20 to 60 ft bgs. The 40 ft of screen in each of these wells allows for determination of a vertical profile of the groundwater within the limits (depths) of the screen.

This profile will include taking field measurements of the conductivity, pH, and temperature of the groundwater. This data will be collected by slowly moving a Troll 8000 (a down-hole logging instrument equipped with conductivity, pH, and temperature probes) down the well and taking readings at 5 ft intervals from 20 to 60 ft bgs.

Low flow groundwater samples will also be collected from these same intervals using a peristaltic pump. A 500 ml filtered (using a 0.45 µ filter) sample will be collected and sent to the Environmental Sciences Lab (ESL). These groundwater samples will be analyzed at the ESL for conductivity, pH, groundwater density, uranium, chloride, sulfate, and ammonia. A 100-ml split from the original 500 ml sample will be prepared and sent to the Grand Junction Office Analytical Laboratory for total dissolved solids analysis.

Because each observation well only contains a 5 ft screen, it is not practicable to complete a vertical profile within these wells. Only one sample (within the screened interval) will be collected from each observation well, with the same analysis as discussed for the samples collected from the pumping wells.

In addition to collecting data at the three pumping well clusters, similar data will also be collected from a well completed in a known freshwater zone to provide additional data regarding the conductivity range of the freshwater zone.

5.2 Field Test

The field test will be initiated after analysis of the reconnaissance groundwater characterization data. The field study will consist of up to three tests that will be completed at each of the pumping well clusters (one test per location). As opposed to traditional aquifer tests, the main objective of these tests will not be to determine the hydraulic properties of the aquifer. Instead, the impact on the freshwater/brine interface and the brine groundwater zone will be the focus of these tests. Collection of hydraulic data is a secondary objective.

Each observation well will be equipped with a Troll 8000 inside the screened interval to measure the conductivity, pH, and temperature changes during the pumping and recovery phase of each test. A Troll 8000 instrument will also be installed below the pump in the pumping well to monitor these groundwater parameter changes within the pumping well. Troll 8000 instruments also equipped with pressure transducers that will monitor water level changes during the tests.

Attached to the end of each Troll 8000 will be the intake of a peristaltic pump that will be used to collected groundwater samples at various time intervals during the tests. At a minimum, samples will be collected for ammonia analysis (to be completed at the ESL) during the first hour of the test, 12 hrs into the test, and prior to the end of the pumping phase. Any drastic changes in the groundwater conductivity may warrant additional sampling.

All groundwater generated by these tests will be discharged onto the ground in areas of known surface contamination. Under no circumstances will discharge water be allowed to flow over the surface and migrate towards the Colorado River.

The pump intake depth will be one of the main factors to be studied during this investigation. The depth of the pump intake, and the relative distance to the top of the freshwater/brine interface will be taken into consideration when reviewing the data collected from these tests. One goal is to determine a relationship between pumping rate, pumping depth, and depth to the interface that may be applied to the area of the site containing the brine zone.

At the SMI–PW01 location, the pump will be set within the top 10 ft of the screen (the pump intake will be set between 20 and 30 ft bgs). An initial pumping rate of 15 gpm will be used at the start of this test. If after 2 hrs of pumping at this rate there is no indication of impacting the freshwater/brine interface zone (as determined by constant or decreasing conductivity), the test will be run for 24 hrs. After 24 hrs of pumping, the pump will be turned off and the recovery portion of the test will begin. The recovery phase of the test will run as long as necessary to determine the time required for the brine zone (if impacted later in the test) to return to background conditions.

If there is evidence of up coning during the first 2 hrs of the test (as determined by increasing conductivity), the pump will be shut off and the subsurface will be allowed to return to background conditions. The test will then be re-started at a lower pumping rate. The goal of this first test is determine the maximum pumping rate that does not impact the interface zone. If the data indicate no impact at 15 gpm, the pumping rate will be increased to 30 gpm, and a similar test will be conducted. A maximum pumping rate of 60 gpm will be used if no impact is detected in the 30 gpm test.

Once the test is completed at the SMI–PW01 location, the equipment will be transferred to the SMI–PW02 cluster for a second test. The procedure will be the same as discussed above, however, the pump intake for this test will be set within the bottom 10 ft of the pumping well (pump intake set 50 to 60 ft bgs). Data collected from this test will determine if groundwater removed from an area close to the freshwater/brine interface will impact the system and result in brine up coning. The pumping rate will depend on the results of the SMI–PW01 test.

If time allows, an additional test will be conducted using the PW01 location subsequent to the PW02 testing. This test will involve setting the pump within the bottom 10 ft of the screened interval of well PW01, and running a test using the same pumping rate as one of the previous PW01 tests. The results from these tests with similar pumping rates, which will be identical with the exception of the pump location, will be compared to determine if groundwater is being withdrawn from 1) the entire screen level, 2) only from the adjacent to the pump intake, or 3) from a preferential pathway zone within the screen interval (if one exists).

In the event all the previously mentioned tests are completed prior to the end of this field effort, a test will be completed at the PW03 location. Test procedures will be identical to the testing at the PW01 and PW02 locations, with the exception of the pump intake location. The pump will be set between 35 and 45 ft bgs in well PW03 for this test, with a pumping rate that will be dependent upon the PW01 and PW02 testing results.

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6.0 Health and Safety

The site-specific Health and Safety Plan (DOE 2001) has been prepared for the Moab Project in accordance with the requirements of 29 CFR 1910.120. All fieldwork will be performed according to the site-specific health and safety requirements developed for this task (DOE 2001).

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7.0 Regulatory Compliance

Areas where aquifer testing is to occur should be scanned for the presence of surface contamination. If the surface contamination exceeds the UMTRA surface remediation standard of 5 picocuries per gram above background, both solid and liquid investigation-derived waste (IDW) can be disbursed in the area around the well. If the testing locations are identified as not contaminated, disposition of these waters is dependent on the contaminant concentrations as defined by the maximum concentrations of each contaminant identified at the site or by specific analytical data representative of groundwater IDW. Environmental Sciences staff will need to verify requirements for disposition of aquifer test waters. In no case will liquid IDW be allowed to reach the Colorado River.

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8.0 References

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